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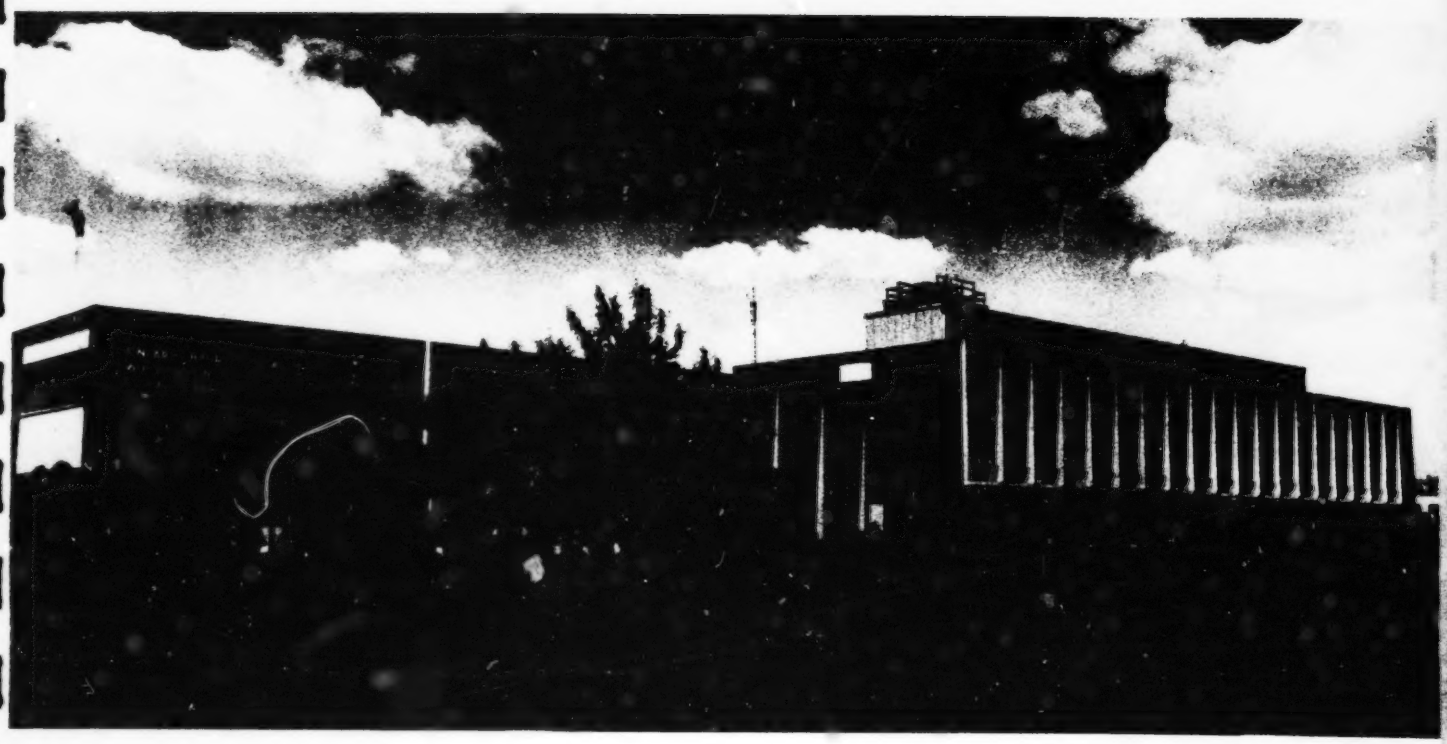

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WINTER RESIDENCY OF GIZZARD SHAD IN DISCHARGES 1979-80

Report No 83-372-K

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ABSTRACT

Winter residency of gizzard shad (*Dorosoma cepedianum*) at three thermal and two non-thermal (river mouth) discharge locations was studied during the period December 1979 to March 1980. Abundance of shad at R.L. Hearn and Pickering NGS 'A' discharges greatly exceeded that recorded at Lakeview GS and non-thermal discharge locations. A greater overall mean electrofishing catch rate occurred at R.L. Hearn GS discharge (2.9 shad/min) than at Pickering NGS 'A' discharge (1.1 fish/min). No fish were captured by electrofishing at non-thermal discharges. Gizzard shad populations at the R.L. Hearn GS and Pickering NGS 'A' discharges were estimated to be about 12,519 and 12,736 respectively, and consisted mainly of adult fish (>310 mm fork length) aged 3+ to 6+. The maximum recorded period of discharge residency was 74 days in the R.L. Hearn GS discharge.

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To Mr. F.J. Kee
Director of Research

WINTER RESIDENCY OF GIZZARD SHAD IN DISCHARGES, 1979-80

1.0 INTRODUCTION

Over the past decade winter impingement of gizzard shad (*Dorosoma cepedianum*) at Ontario Hydro generating facilities on the Great Lakes has caused growing concern from both an operational and an environmental standpoint. In the winter of 1970 massive impingement of shad at Lambton GS overloaded the fish handling system resulting in the channelling of several thousand dead and dying shad into the discharge. During the winter of 1975-76 impingement of 45,000 kg of shad at the same station caused the collapse of the intake screens, blockage of cooling water flow and passage of some fish into the condenser boxes (Ontario Hydro Research Division Report No 77-400-K). Operational difficulties directly attributed to shad impingement have also occurred at R.L. Hearn GS, Lakeview GS and Pickering NGS 'A'.

In an effort to gain a better understanding of the factors leading to shad impingement, a fish residency study was undertaken during the winter of 1979-80. The five locations included in the study were the discharge areas of Pickering NGS 'A', Lakeview GS, R.L. Hearn GS, and the mouths of Duffin Creek and the Credit River. The objectives for this study were to:

(i) determine if the Pickering NGS 'A', Lakeview GS and R.L. Hearn GS thermal discharges act as principal foci for winter residence of gizzard shad, or whether non-thermal discharges attract gizzard shad to the same extent;

(ii) document the period of winter residence of gizzard shad in the discharge areas;

(iii) estimate the number of gizzard shad resident in the discharge areas and examine age and length frequencies as well as stomach contents of these fish.

2.0 METHODS

Experimental gill nets and an electroshocker were used to collect gizzard shad at the five sampling locations shown in Figure 1. Weather and ice conditions prevented sampling on several occasions. The number of actual days spent fishing at each location are presented in Table 1. Sampling was conducted from December 1979 to March 1980.

2.1 Electrofishing

Electrofishing equipment consisted of a Smith-Root Mark VI electroshocker mounted on a 7 m boat. The electroshocker was operated on a pulsed direct current (DC) mode at about 60 pulses per second (pps) and a pulse width (duration of electric current flow) of about 4 ms. A pulsed DC field generally produces a strong electrotaxic effect and is often used in fishery work (Northrop, 1967).

Gizzard shad caught were marked with numbered T-type Floy tags inserted at the posterior base of the dorsal fin, measured for fork length and released. Fish recaptured from electrofishing and gill netting were recorded for population estimation and determination of movement. Fishing time in seconds of electroshocking was recorded to derive a catch per unit effort (CUE) defined as the number of shad captured per minute. Subsamples of up to 10 shad per location were taken for fork length, age and stomach content analyses. Catch of other fish species was also recorded. Shad stomach contents were obtained according to the method outlined in Ontario Hydro Research Division Report No 77-400-K.

2.2 Gill Nets

Gill nets were set for one 24 h period on each sampling occasion. A single gill net gang consisted of 8-15 m panels ranging in mesh size from 3.8 cm to 12.7 cm in 1.3 cm increments. Total fish catch was recorded. Gill nets were set parallel to the main current flow close (100-200m) to each discharge (Figure 1).

2.3 Population Estimation

The Schnabel multiple mark method (Ricker, 1975) was used to estimate the population sizes of gizzard shad at locations where sufficient fish were captured. This technique is based on the following assumptions:

(i) marked fish mix thoroughly into the population;

(ii) both marked and unmarked fish are equally susceptible to fishing and natural mortality;

(iii) tags are not lost from the fish and when recaptured all tags are reported;

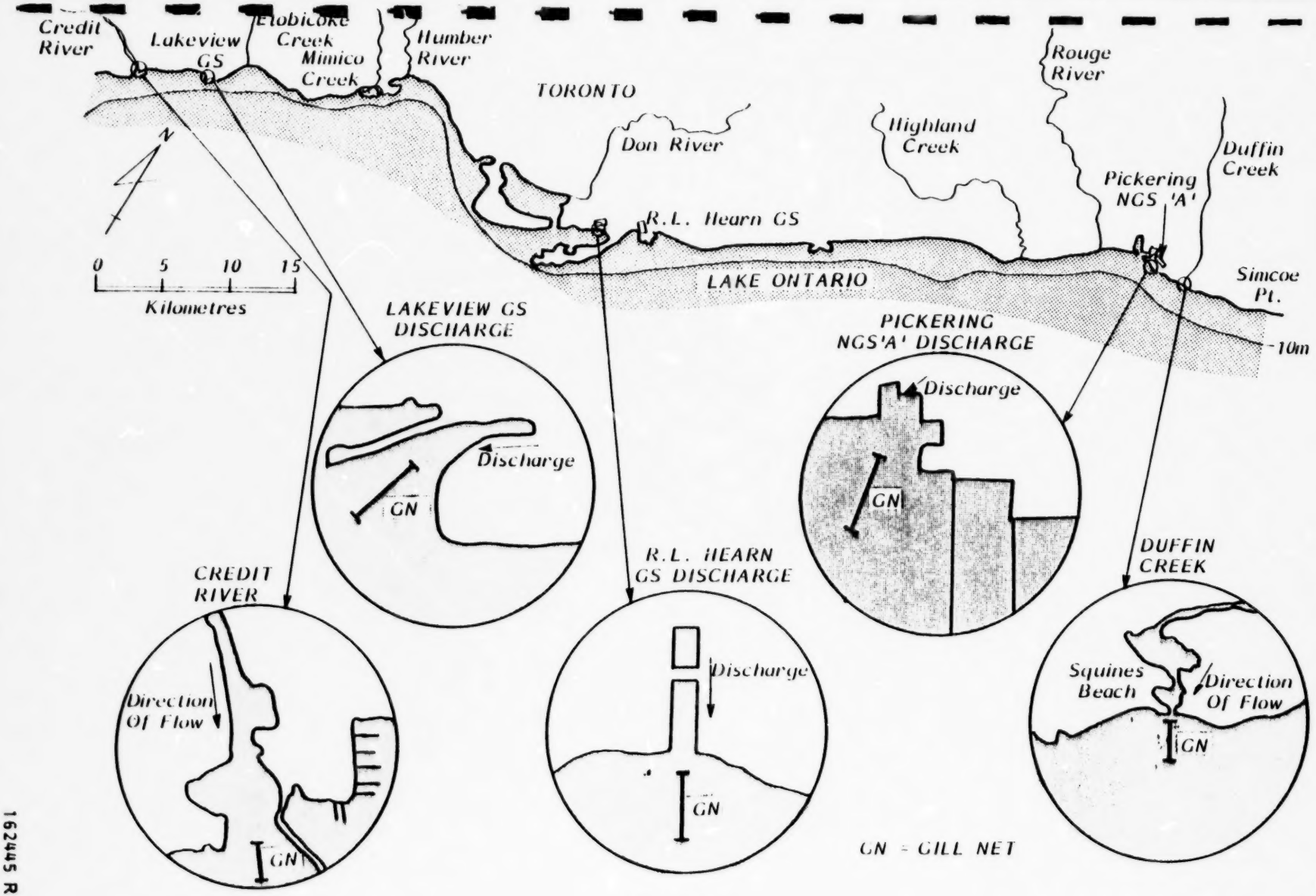

FIGURE 1

SAMPLING LOCATIONS FOR GIZZARD SHAD WINTER RESIDENCY STUDY 1979-80

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TABLE 1

FISHING FREQUENCY AND DATES FOR EACH SAMPLING LOCATION

	Credit River	Lakeview GS Discharge	RL Hearn GS Discharge	Pickering NGS 'A' Discharge	Duffin Creek
Electrofishing: Frequency (days)	5	5	10	13	1
Dates	Dec 3, 17,18 Jan 23 Feb 21	Dec 4,17,18 Jan 23 Feb 21	Dec 5,6 Jan 9,10, 24,25 28,29 Mar 24,25	Dec 10,13 Jan 15,16, 17 Feb 5,6,7, 8,12,15 Mar 10,14	Mar 12
Gill Nets: Frequency (days)	2	2	3	4	3
Dates	Jan 22 Feb 21	Jan 22 Feb 21	Jan 9,29 Mar 25	Jan 15 Feb 5,20 Mar 5	Jan 17 Feb 5 Mar 6

(iv) recruitment immigration to and emigration from the population are negligible while marks are being recovered.

The Schnabel formula is $N = \frac{\Sigma(C_t M_t)}{\Sigma R_t}$

where, N = population estimate

C_t = total catch on each sampling day t

M_t = number of marked fish at large on day t

R_t = number of recaptures in catch C_t.

Confidence limits (95%) were calculated by treating R as a Poisson variable and obtaining values from a Poisson frequency distribution table (Ricker, 1975).

3.0 RESULTS AND DISCUSSION

3.1 Catch Composition

Electrofishing and gill netting activities at the five sampling locations produced a total of 2006 fish (Table 2). The majority of fish were captured in the Pickering NGS 'A' and R.L. Hearn GS discharges and consisted mainly of gizzard shad (68%). Fish species captured in moderate numbers included white sucker (10%), carp (9%) and white bass (4%) (Table 2).

Twenty-one (21) fish species were caught during the sampling period, with the maximum number of species (for both fishing methods combined) occurring at Pickering NGS 'A' discharge (18). Fish species were not as numerous at the other four sampling locations (Table 2).

3.2 Gizzard Shad Distribution

Total gizzard shad catch varied considerably between the five sampling locations. Highest catches occurred at Pickering NGS 'A' discharge (688 fish) and R.L. Hearn GS discharge (660 fish), while low catches were recorded at Duffin Creek (10 fish) and Lakeview GS discharge (8 fish). No gizzard shad were captured at the Credit River during this study.

The temporal distribution of gizzard shad captured in experimental gill nets and by electrofishing at Pickering NGS 'A' and R.L. Hearn GS discharges is presented in Figure 2. Gizzard shad abundance, as reflected in gill net catches, peaked on February 20, 1980 when 142 fish were taken at Pickering NGS 'A' discharge. Electrofishing at the same location from February 8-12, 1980 also produced moderately large numbers of gizzard shad, suggesting that the Pickering NGS 'A' discharge was a preferred location for gizzard shad during

Table 2

Summary of Total Fish Catch Obtained from December, 1979 - March, 1980

Fish Species	Pickering NGS "A" Discharge		R.L. Hearn GS Discharge		Lakeview GS Discharge		Duffin Creek		Credit River		Total Caught	%
	Electro-fishing	Gill Net	Electro fishing	Gill Net	Electro-fishing	Gill Net	Electro fishing	Gill Net	Electro-fishing	Gill Net		
Gizzard Shad (*Dorosoma cepedianum*)	408	788	618	42	1	7	0	10	0	0	1366	68.09
White Sucker (*Catostomus commersoni*)	18	31	0	0	75	4	2	27	1	21	190	9.47
Carp (*Cyprinus carpio*)	119	40	0	0	12	2	0	1	1	0	175	8.72
White Bass (*Morone chrysops*)	60	10	0	0	0	0	0	0	0	0	70	3.49
Smelt (*Osmerus mordax*)	0	20	0	5	0	0	0	15	0	1	41	2.04
White Perch (*Morone americana*)	20	15	0	4	0	0	0	1	0	0	40	1.99
Walleye (*Stizostedion vitreum*)	2	31	0	0	0	0	0	0	0	0	33	1.65
Brown Trout (*Salmo trutta*)	6	13	1	8	0	0	0	1	0	0	33	1.65
Small mouth Bass (*Micropterus dolomieu*)	16	0	0	0	0	0	0	0	0	0	16	0.80
Coho Salmon (*Oncorhynchus kisutch*)	0	1	0	0	2	4	0	0	2	0	9	0.45
Rainbow Trout (*Salmo gairdneri*)	2	1	0	0	1	1	0	0	0	0	9	0.45
Spottail Shiner (*Notropis hudsonius*)	0	0	0	5	1	0	0	0	1	0	7	0.3%
Yellow Perch (*Perca flavescens*)	0	2	0	3	0	0	0	0	0	0	5	0.2%
Northern Pike (*Esox lucius*)	0	2	0	1	0	0	0	0	0	0	3	0.15
Round Whitefish (*Prosopium cylindraceum*)	0	1	0	0	0	0	0	1	0	0	2	0.10
Redhorse Sucker (*Moxostoma macrolepidotum*)	0	0	0	0	0	0	0	0	1	1	2	0.10
Chinook Salmon (*Oncorhynchus tshawytscha*)	0	1	0	0	0	0	0	0	0	0	1	0.05
Alewife (*Alosa pseudoharengus*)	0	0	0	1	0	0	0	0	0	0	1	0.05
American Eel (*Anguilla rostrata*)	1	0	0	0	0	0	0	0	0	0	1	0.05
Largemouth Bass (*Micropterus salmoides*)	0	1	0	0	0	0	0	0	0	0	1	0.05
Emerald Shiner (*Notropis atherinoides*)	0	1	0	0	0	0	0	0	0	0	1	0.05
Totals	644	463	621	69	94	18	2	58	6	31	2006	
(No of Species)	(10)	(16)	(2)	(8)	(6)	(7)	(1)	(7)	(5)	(3)	(21)	

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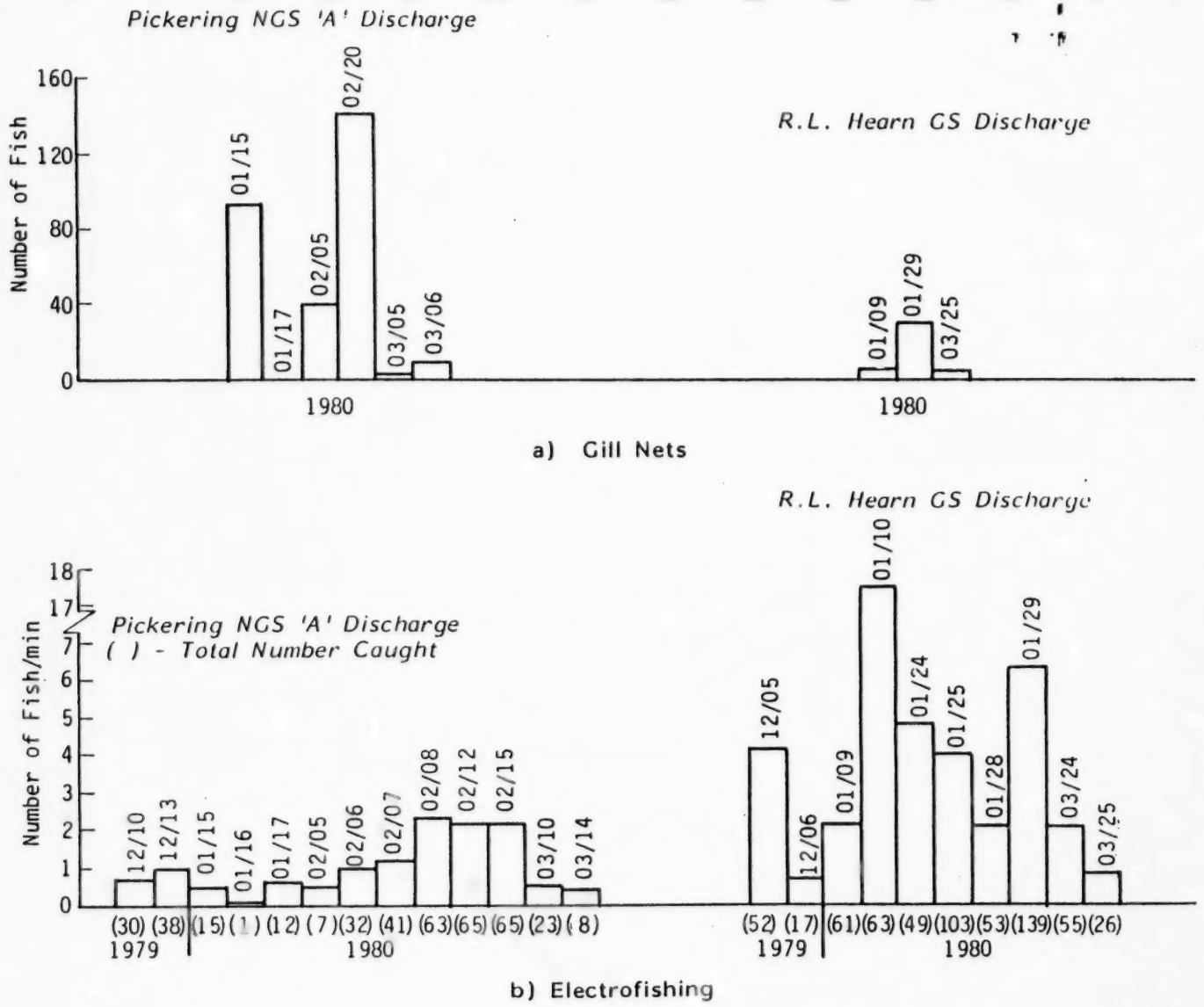

FIGURE 2

GIZZARD SHAD CATCH FREQUENCY AT PICKERING NGS 'A' AND R.L. HEARN GS DISCHARGES a) IN GILL NETS AND b) BY ELECTROFISHING DURING DECEMBER, 1979 - MARCH, 1980

the second and third weeks of February 1980. The gill net catch of gizzard shad on January 15, 1980 was also relatively high (92 fish), but only 15 fish were electrofished (Figure 2). On all other sampling occasions the number of gizzard shad collected at the Pickering NGS 'A' discharge (by either fishing method) did not exceed 40 fish. Generally fish capture success at this location was high.

At R.L. Hearn GS discharge gill net catches of gizzard shad were small (maximum = 27 fish), and no specific temporal pattern of distribution was observable, although gill net sampling was more sporadic than that conducted at the Pickering NGS 'A' discharge (Figure 2). Electrofishing results indicated that at R.L. Hearn GS discharge gizzard shad catches were generally greater during January, with the highest catch per unit effort (17.5 fish/min) occurring on January 10, 1980.

Electrofishing may be more indicative of the relative abundance of gizzard shad in the discharge locations than gill net fishing. Gill nets set parallel to the discharge flows catch fish moving in a transverse direction (across the discharge area) and catch success is thus dependent on fish mobility. Electrofishing is an active fishing technique which does not necessarily require movement by fish to enhance the catching efficiency (Hartley, 1980). At both Pickering NGS 'A' and R.L. Hearn GS discharges consecutive electrofishing sequences sometimes resulted in an increased gizzard shad catch on the second consecutive day (Figure 2). This result was probably due to the process of concentrating electrofishing effort in the same vicinity during a two-day sequence, since fish density is often regarded as being roughly proportional to electrofishing catch efficiency (Hartley, 1980).

Although the data show a trend of increasing gizzard shad catches with time, especially at Pickering NGS 'A' discharge (Figure 2), fish accumulation (ie adult fish recruitment) probably did not occur continually over the winter, since ambient lake temperatures were cold enough (1-2°C) to be lethal to lake-resident fish. Very few shad were captured at the control sampling locations.

Variability in fishing effort was evident at both Pickering NGS 'A' and R.L. Hearn GS discharge locations, since electroshocking time often differed considerably from one sampling day to the next. The variable catch rate was likely related to diurnal changes in fish distribution within each discharge.

Over the entire electrofishing period the average gizzard shad catch per minute of electroshocking (total catch/total time) was 2.9 fish/min at R.L. Hearn discharge and 1.1 fish/min at Pickering NGS 'A' discharge. This result is likely due to the large temperature difference between the two discharges. Whereas Pickering NGS 'A' surface discharge temperature ranged between 12.1 and 16.6°C, surface temperature at R.L. Hearn GS discharge fluctuated

between 3.4 and 11.4°C during the sampling period (Table 3). A temperature effect is possible since gizzard shad are known to undergo cold narcosis and loss of equilibrium (making them more susceptible to capture) when exposed to low temperatures (Cox and Coutant, 1976). It is noteworthy that the maximum gizzard shad catch per unit effort during electrofishing at R.L. Hearn GS discharge (17.5 fish/min) occurred at a surface discharge temperature of only 4.0°C while the minimum CUE 90.7 fish/min) was recorded at a temperature of 10.6°C (Table 3).

Mean daily flow rates for R.L. Hearn GS discharge were lower than those at Pickering NGS 'A' discharge (Table 3). To determine whether the observed difference in catch rate between the two discharges (2.9 and 1.1 fish/min at R.L. Hearn GS discharge and Pickering NGS 'A' discharge, respectively) held when flow rates were considered, a mean catch statistic was calculated for each location according to the formula:

$$\bar{C} = \frac{\sum_{i=1}^{n} (C_i/FR_i)}{n}$$

where, C_i = fish catch on i^{th} day

FR_i = mean daily discharge flow rate on i^{th} day (m^3/sec)

n = number of sampling days.

The value obtained for R.L. Hearn GS discharge (3.42) was significantly greater than that calculated for Pickering NGS 'A' discharge (0.32) ($t_{[21]} = 38.55$; $p<0.001$). This result confirms that, on the average, significantly more gizzard shad were caught in the former discharge area.

Thus, the smaller, cooler thermal outfall of R.L. Hearn GS apparently concentrated gizzard shad within a small area, increasing their vulnerability to electroshocking. The larger, warmer Pickering NGS'A' discharge likely facilitated greater shad movement over a broad area, decreasing the chance of being captured by electrofishing while increasing the opportunity for capture by gill nets (due to increased fish movement).

There was no apparent relationship between fish catch and either secchi depth, wind speed or wind direction at any location sampled.

3.3 Population Structure

3.3.1 Population Size and Residency

Schnabel multiple census population estimates were calculated for gizzard shad in the R.L. Hearn GS and Pickering NGS 'A' discharges. (Table 4). The gizzard shad population at the R.L. Hearn GS discharge was estimated at 12,519, with the 95% confidence interval

TABLE 3

DISCHARGE TEMPERATURE AND MEAN DAILY FLOW RATE
ON SAMPLING DAYS AT PICKERING NGS 'A'
AND R.L. HEARN GS DISCHARGES

Location	Date	Discharge Temperature (°C)	Mean Daily Flow Rate (m^3/sec)
Pickering NGS 'A' Discharge	Dec 10, 1979	15.1	100
	Dec 13, 1979	15.3	101
	Jan 15, 1980	14.5	94
	Jan 16, 1980	12.1	94
	Jan 17, 1980	12.4	92
	Feb 5, 1980	16.4	97
	Feb 6, 1980	12.6	93
	Feb 7, 1980	12.6	98
	Feb 8, 1980	16.0	99
	Feb 12, 1980	16.6	98
	Feb 15, 1980	16.0	97
	Mar 10, 1980	15.0	91
	Mar 14, 1980	13.2	88
R.L. Hearn GS Discharge	Dec 5, 1979	11.4	20
	Dec 6, 1979	10.6	16
	Jan 9, 1980	3.6	20
	Jan 10, 1980	4.0	21
	Jan 24, 1980	5.2	17
	Jan 25, 1980	4.6	17
	Jan 28, 1980	4.5	17
	Jan 29, 1980	3.4	17
	Mar 24, 1980	5.7	20
	Mar 25, 1980	5.6	20

TABLE 4

SCHNABEL MULTIPLE MARK-RECAPTURE CONTINGENCY TABLE DATA FOR GIZZARD SHAD TAKEN AT R.L. HEARN GS AND PICKERING NGS 'A' DISCHARGES

Location	Date	Number Caught C_t	Recapture R_t	Number Marked (less removals)	Marked Fish at Large ΣM_t	$C_t \Sigma M_t$
Pickering NGS 'A' Discharge	Dec 10	30	0	30	0	0
	Dec 13	38	0	38	30	1140
	Jan 15	15	0	15	68	1020
	Jan 16	1	0	1	83	83
	Jan 17	12	0	12	84	1008
	Feb 5	7	0	7	96	672
	Feb 6	32	1	32	103	3296
	Feb 7	41	0	41	135	5535
	Feb 8	63	0	63	176	11088
	Feb 13	65	1	10	239	15535
	Feb 15	65	0	10	249	16185
	Feb 20	0	3	-3	259	0
	Mar 10	23	0	23	256	5888
	Mar 14	8	0	8	279	2232
			5	274		63682
	N (Total Number) = $\frac{63682}{5}$ = 12,736					
R.L. Hearn GS Discharge	Dec 5	52	0	52	0	0
	Dec 6	17	0	17	52	884
	Jan 9	61	0	5	69	4209
	Jan 10	63	1	59	74	4662
	Jan 24	49	1	48	133	6517
	Jan 25	103	5	97	181	18643
	Jan 28	53	1	13	278	14734
	Jan 29	139	0	139	291	40449
	Mar 24	55	2	10	430	23650
	Mar 25	26	0	19	440	11440
			10	459		125188
	N (Total Number) = $\frac{125,188}{10}$ = 12,519					

ranging from 6,355 to 23,183. The gizzard shad population at the Pickering NGS 'A' discharge was calculated to be 12,736 with the lower and upper 95% confidence intervals being 5,434 and 39,736, respectively. Although these population estimates are similar, they are only approximate, as indicated by the broad confidence intervals.

The low number of gizzard shad recaptures at both the R.L. Hearn GS and Pickering NGS 'A' discharges (Table 4) suggests that marked fish either left these discharges or suffered substantial mortality within the discharges over the winter. Mortality of marked gizzard shad after release is unlikely since no dying marked fish were captured in gill nets or observed in surface waters of any discharge. Egress of marked (and unmarked) shad from the discharge areas would expose them to very low ambient temperatures and result in low winter survival for these fish.

However, some shad may withstand short periods of exposure to very cold water. Two shad tagged in the R.L. Hearn GS discharge on January 10 and 29, 1980 were recaptured 41 and 22 days later, respectively, in the Pickering NGS 'A' discharge (Table 5). It is not known how long these fish spent outside of the R.L. Hearn GS and Pickering NGS 'A' discharges, which are about 33 km apart. No information is available on the total number of fish moving from one discharge to another or the frequency with which such excursions occurred over the winter.

Fewer gizzard shad were recaptured at Pickering NGS 'A' discharge than at R.L. Hearn GS discharge (Tables 4 and 5). Several fish recaptured at the latter site had been tagged and released just one day earlier (Table 5), suggesting that these fish probably did not leave the discharge location. One fish was even recaptured on the same day that release occurred (Table 5). Some of these fish were not used to estimate shad population size at R.L. Hearn GS discharge since field observations indicated that a few fish were not completely recovered from fish handling during tagging.

Excluding fish recaptured one day after release, the period between first and second capture of shad ranged from 12-74 days (Table 5). Since no fish were captured at the Credit River sampling location and only a few shad were taken at Duffin Creek, it is reasonable to assume that most shad were discharge residents during the interval between capture and subsequent recovery.

3.3.2 Age and Length Composition

Samples of 81 and 14 gizzard shad collected by electrofishing at Pickering NGS 'A' and R.L. Hearn GS discharges, respectively, were aged and measured for fork length (mm). Fish from both discharge locations were mainly adults between 3+ and 6+ years of age (Table 6). Juvenile gizzard shad were represented by a few 0+ and 1+ fish.

TABLE 5

LIST OF GIZZARD SHAD RECAPTURED IN
R.L. HEARN GS AND PICKERING NGS 'A' DISCHARGES

Recovery Location	Tagging Date	Recapture Date	Days Between Capture
Pickering NGS 'A'	Dec 10, 1979	Feb 6, 1980	58
	Feb 12, 1980	Feb 13, 1980	1
	Feb 8, 1980	Feb 20, 1980	12
	Jan 29, 1980*	Feb 20, 1980	22
	Jan 10, 1980*	Feb 20, 1980	41
R.L. Hearn GS Discharge	Dec 5, 1979	Jan 10, 1980	36
	Dec 5, 1979	Jan 24, 1980	50
	Jan 24, 1980	Jan 25, 1980	1
	Dec 5, 1979	Jan 25, 1980	51
	Dec 5, 1979	Jan 25, 1980	51
	Jan 25, 1980	Jan 25, 1980	0
	Jan 10, 1980	Jan 25, 1980	15
	Jan 10, 1980	Jan 25, 1980	15
	Dec 5, 1979	Jan 28, 1980	54
	Jan 28, 1980	Jan 29, 1980	1
	Jan 28, 1980	Jan 29, 1980	1
	Jan 28, 1980	Jan 29, 1980	1
	Jan 28, 1980	Jan 29, 1980	1
	Jan 28, 1980	Jan 29, 1980	1
	Jan 10, 1980	Mar 24, 1980	74
	Jan 10, 1980	Mar 24, 1980	74

*Shad were tagged in the R.L. Hearn GS discharge.

TABLE 6

AGE DISTRIBUTION AND MEAN FORK LENGTHS OF GIZZARD SHAD SAMPLED FROM R.L. HEARN AND PICKERING NGS 'A' DISCHARGES BY ELECTROFISHING

Location	Age (Years +)							
	0+	1+	2+	3+	4+	5+	6+	7+
Pickering NGS 'A'								
Frequency	1	4	0	6	23	28	19	0
Mean Fork Length (mm)	182	231	0	331	350	357	372	0
R.L. Hearn GS								
Frequency	0	1	0	0	4	5	3	1
Mean Fork Length (mm)	0	256	0	0	323	351	386	370

Shad collected at Pickering NGS 'A' discharge were dominated by 5 year old fish with a mean fork length of 357 mm (Table 6). Although the sample of shad from R.L. Hearn GS discharge was small, it appears that 5+ fish (mean fork length 351 mm) were prevalent there as well. Length frequency distributions of shad tagged at both R.L. Hearn GS and Pickering NGS 'A' discharges show that the majority of shad were between 340 and 370 mm fork length (Table 7). Juvenile shad (considered here to be <250 mm fork length) were absent from these samples. A similar phenomenon was observed for shad which congregated in the Lambton GS discharge during the winter of 1976-77 (Ontario Hydro Research Division Report No 77-400-K). However, experimental electrofishing in the Pickering NGS 'A' discharge in January of 1976 resulted in the capture of 856 juvenile and adult shad (Ontario Hydro Research Division Report No 80-226-K). Thus mixed shad aggregations do occur in discharge locations, but the reason for the conspicuous absence of juvenile shad in this study is unknown. No evidence exists for the spatial segregation of juvenile and adult gizzard shad in the thermal discharges mentioned in this study.

3.3.3 Stomach Content Analysis

Gizzard shad are herbivorous fish which feed on algae, phytoplankton or microscopic plants (Scott and Crossman, 1973). Shad captured at Duffin Creek, Pickering NGS 'A' discharge and Lakeview GS discharge often had substantial proportions (25-90%) of organic detritus in their stomachs, whereas shad collected at R.L. Hearn GS discharge had stomachs that were either empty or contained sand (Table 8). Filamentous algae comprised a maximum of 5% of the stomach contents of the shad taken at the various locations. The balance of the material found in the stomachs of Pickering NGS 'A' shad was usually made up of sand but on two sampling dates (Jan 15 and Feb 20) the proportion of sand exceeded that of organic detritus (Table 8).

These data suggest that gizzard shad resident in discharges during the winter do ingest organic material (some in the form of filamentous algae) along with variable quantities of sand. Notably, shad had little or no stomach contents at R.L. Hearn GS discharge, where fish density was high compared with that at Pickering NGS 'A' discharge. It is possible that the cooler water associated with the R.L. Hearn GS discharge may have prevented fish from feeding outside of the immediate discharge area. The more extensive Pickering NGS 'A' discharge plume has been observed to cover a shallow, vegetated area near Frenchman Bay during early winter (Ontario Hydro Research Division Report No 80-226-K). Thus an available food source (aquatic plant material) may exist near the Pickering NGS 'A' discharge and could account for the presence of algae and organic detritus in the stomachs of shad taken near this discharge.

Table 7

Length Frequency Distributions of Gizzard Shad Collected by Electrofishing at R.L. Hearn GS and Pickering NGS 'A' Discharges

Fork Length Interval (mm)		280-289	290-299	300-309	310-319	320-329	330-339	340-349	350-359	360-369	370-379	380-389	390-399	400-409	410-419	420-429	430-439	440-449	450-459	460-469
Frequency	R.L. Hearn GS	1	-	-	3	19	38	78	76	79	73	50	36	20	11	6	-	1	-	-
	Pickering NGS 'A'	-	-	-	2	7	25	27	37	30	33	12	22	10	5	1	2	-	-	1

TABLE 8

SUMMARY OF MEAN PERCENT COMPOSITION OF STOMACH CONTENTS OF GIZZARD SHAD COLLECTED AT PICKERING NGS 'A' R.L. HEARN GS, LAKEVIEW GS DISCHARGES AND DUFFIN CREEK

Description of Contents	Pickering NGS 'A'					R.L. Hearn GS		Lakeview GS		Duffin Creek
	Dec 10	Jan 15	Feb 8	Feb 20	Mar 5	Jan 22	Mar 25	Dec 4	Mar 20	Mar 6
Sand	25	47	7	83	60	33	0	36	45	0
Organic Detritus	70	25	84	16	7	0	0	7	48	89
Filamentous Algae	5	<1	0	1	0	0	0	0	3	1
Inverte-brate Remains	0	<1	2	0	0	0	0	0	0	0
Miscellaneous	0	<1	1	0	0	0	0	0	4	0
Empty	0	27	7	0	33	67	100	57	0	10
(No of Fish Examined)	(10)	(37)	(14)	(6)	(3)	(9)	(9)	(7)	(5)	(10)

4.0 SUMMARY

(1) Over 12,000 gizzard shad were estimated to reside in each of the Pickering NGS 'A' and R.L. Hearn GS discharges during the winter of 1979-80. Very few gizzard shad were caught at Lakeview GS discharge or at the mouths of Duffin Creek or Credit River.

(2) The maximum estimated period of winter residence of gizzard shad was 74 days, and occurred from January 10, 1980 to March 24, 1980 in the R.L. Hearn GS discharge.

(3) Averaged over the entire sampling period a significantly ($p<0.001$) greater number of gizzard shad were captured (per mean daily discharge flow rate) at R.L. Hearn GS discharge (3.42) than at Pickering NGS 'A' discharge (0.32). This result was likely related to the differences in thermal and flow characteristics between the two discharges.

(4) Gizzard shad populations at Pickering NGS 'A' and R.L. Hearn GS discharges consisted mainly of 3+ to 6+ year-old adults which ranged in fork length between 310 mm and 469 mm.

(5) Gizzard shad resident in Pickering NGS 'A' discharge ingested substantially more organic material than shad resident in R.L. Hearn GS discharge. Fish captured at all thermal discharge areas had moderate to high proportions of sand remaining in their stomachs.

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POOR

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